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COMPONENTS FOR THE PREPARATION OF FILLINGS THAT DO NOT LEAVE MARGINAL GAPS AND THAT ARE MADE OF LIGHT-CURABLE PLASTIC FILLING MATERIALS FOR HUMAN TEETH

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COMPONENTS FOR THE PREPARATION OF FILLINGS THAT DO NOT LEAVE MARGINAL GAPS AND THAT ARE MADE OF LIGHT-CURABLE PLASTIC FILLING MATERIALS FOR HUMAN TEETH

[Komponenten für die Herstellung randspaltfreier Füllungen aus lichthärtbaren plastischen Füllungsmaterialien für menschliche Zähne]

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The following statements are taken [unedited] from the documents submitted by the applicant.

Definition of the problem

Light-curable plastic materials, so-called composites, have been used in dentistry for more than 10 years to produce fillings for teeth. These have been used effectively and reliably to fill small defects (cavities) that do not have to withstand a high mechanical stress. But when teeth with large cavities are involved, one considerable problem that must be overcome is that in the course of the polymerization, the composite material with which the dental cavity in the mouth is filled shrinks noticeably. Thus, after polymerization, the filling obtained is unable to fill the complete cavity: Instead gaps form in the transition zone from the composite material to the tooth. These gaps can damage the tooth considerably in that, e.g., the gap areas are colonized by bacteria which can again cause caries. To solve this problem, a number of different approaches

have been suggested. The prior-art methods aiming at preventing the formation of marginal gaps cannot be routinely used in patients because such methods take an inordinately long time: the step-by-step process of building up a large filling from numerous separately and successively added composite layers with light-curing times in between requires an inordinately large expenditure of time both for the dentist and for the patient.

Attempts to influence the shrinkage by polymerization by means of a targeted exposure of the filling to light through the wall of the tooth, however, have not met with success. In the most recent research conducted in this area (Hoff 1997), it was found that the light-conducting properties of the dentin made this practically impossible. The incorporation of premanufactured macroscopic filler bodies, so-called inserts, was a step in the right direction but met with only limited success: although the insert as such does not shrink, the composite material surrounding it does shrink uncontrollably during polymerization. As a result, undesirable gaps continue to form between the filling and the tooth.

The invention which is identified in the claims and the technical embodiment of which is described in the text below as well as in the claims offers a new possibility of solving the problems defined above. In particular, using a suitable combination of the components of the present invention, it is possible to control, by way of exposure to light, the polymerization of the composite material or of other plastically workable light-curable filling materials in the dental cavity so that -- in contrast to the technique employed so far -- the cure shrinkage is compensated for in that additional plastic filling material is allowed to flow into the cavity. Using the required light intensity and energy dose -- e.g., through the use of suitable lasers or another light exposure apparatus -- via a light insert, a curing front results which starts on the surface of the light exit window of the light insert and spreads through the filling and which eventually reaches the peripheral regions of the cavity. As a result, it is ensured that, during the curing process, filling material which is still plastic flows into the cavity, which prevents, in particular, the formation of a gap in the marginal region between the filling and the tooth. Only thereafter does an after-cure of the filling material take place by means of exposing the overall surface to light.

The conventional techniques to date did not make it possible to compensate for the cure shrinkage: because of the exposure to light from an external source, the external portions of the filling material polymerized first in the regions of high light intensity, which made it impossible for additional filling material to flow in so as to compensate for the shrinkage.

Prior to the complete cure of the plastic filler portion, movements of the light insert can have a destabilizing effect on the adhesive bonding between the light insert and the filling and/or the adhesive bond between the filling and the tooth cavity. To avoid this problem, the light transmission, especially during the first phase of the exposure to light, should either be contact-free or should take place by means of a flexible light conductor.

One component of the invention -- hereinafter called light insert (Figure 2) -- is designed so as to fulfill a light-conducting and/or light-distributing function. As seen in Figure 1, the light insert (1) is preferably introduced into the filling material (3) which is still soft and which fills the tooth cavity (4). By exposing only the light insert with a light exposure device suitable for this purpose (Figure 3: (6)), this device being an element of the present invention, the light is conducted into the filling so as to ensure that this filling is cured starting in the area of contact between the insert and the composite material. In addition, the filling, including the light insert, is finally exposed to light as usual; this then leads to the complete cure. The light exposure device makes it possible both to expose the composite material solely via the light insert and to expose the overall filling, including the light insert. One possibility is to leave the light insert in the filling into which it has been introduced. Any parts of the light insert that protrude from the filling are ground down by means of the conventionally used dental instruments. Another possibility is to remove the light insert from the cured filling. The cavity thus formed in the filling can subsequently be filled either with a suitable filling material or with a premanufactured fitting piece that is cemented in place. By matching the colors of the filling materials and the fitting piece to the color and translucence of the natural tooth, esthetically especially favorable results can be achieved. Similar good esthetic results can be obtained if, when using the light insert which leaves a large cavity, a fitting piece of suitable color and translucence is introduced into said cavity once the light-curable filling material has been fully cured.

To solve the problem of the technical design of the light insert, several advantageous approaches present themselves.

a) An embodiment of the light insert which is made of a material that is permeable to light. The material used can be an organic and/or inorganic material. The light insert (Figure 2) has one or a plurality of light entry windows (1) and one or a plurality of light exit windows (2) which extend completely or partially over the area of contact between the light insert and the filling. The light windows are designed to ensure that they allow the highest possible light flux from the light exposure device into the inside of the light insert and from the inside of the light insert into the surrounding filling material.

b) An embodiment similar to the one mentioned under a), except that the light insert is additionally coated with a completely and/or partially cured filling material. In this manner, it is possible to promote the adhesive bonding of the light insert introduced into the plastic filling material. If mineral light insert bodies are used, the adhesive bond with the light insert can be stabilized by first silanizing the mineral contact surface.

c) An embodiment as described under a) and/or b), wherein the light insert body consists of one or a plurality of light-conducting elements.

d) An embodiment as described under c), wherein the light insert has a cavity starting in the location of the light entry window and being open toward the light entry window or being covered so as to allow passage of light, through which cavity the light exposure can be carried out completely or partially.

e) An embodiment as described under c), wherein the light insert body is constructed based on the physical principle of a "photonic crystal."

f) An embodiment as described under c),wherein the light insert body is constructed based on the principle of a light conductor having different refractive indices.

Preferable, embodiments a) through f) have in common that the light intensity that is transmitted from the light insert into the surrounding filling material is high throughout the area of contact between the light insert and the filling. This type of light transmission can be achieved, e.g., by means of sandblasting the surface of the light exit window of the light insert that is intended to contact the filling material. The light entering the light insert can also be reflected or distributed into the surrounding filling material by means of light scattering centers inside the light insert material. This makes it especially suitable for optimally transmitting the light into the surrounding area of the light insert within the desired time, at the desired intensity, and in the desired direction.

Of special importance to the technical implementation of the light insert are the light entry window, the light exit, and the adhesive bond between the material of the light insert and the filling. To transmit light from the light exposure device to the light insert, it may be useful to utilize a low-loss light coupling. This can be implemented, e.g., by means of smooth and/or antireflection-coated surfaces on the light entry windows. Potential light intensity losses at the light entry windows of the light insert can be compensated for by a higher-power light exposure source.

The initial exposure of the filling material to light, which takes place solely via the light insert and thus via the light exit window of said light insert, requires either a matching light source that is adapted to the geometry of the light entry window of the light insert or a suitable cover for the free surface of the filling material adjacent to the light in the form of a diaphragm (Figure 1: (2)), thus ensuring that in cases in which the overall area is conventionally exposed using a conventional light exposure device, the light is initially able to penetrate the filling material only by way of the light insert. After removal of the diaphragm, the filling material and the light insert are subsequently exposed in a conventional manner. For this approach, it is recommended that an adapter (Figure 3: (5)) be used which optically couples the light exit window of the light exposure device (Figure 3: (8)) to the light entry window of the light insert (Figure 3: (7)).

To facilitate the flow of the filling material to the light insert during the incorporation of said filling material into the cavity filled with the filling material, it may be useful if the light exposure device has a built-in shaking device, the vibrations of which are transmitted via a suitable connection to the light insert.

To expose the composite material to light, it may also be useful to have a light exposure source with an adjustable light exit window and a controllable light intensity and light divergence. This makes it possible, in particular, to reproducibly optimize the light flux by means of which the undesirable shrinkage of the filling material is minimized or stopped.

Claims

1. Light inserts for the manufacture of tooth fillings that do not leave marginal gaps and that are made of plastically workable light-curable filling materials and for the permanent or short-term indwelling in the filling of the tooth, characterized in that the light inserts have a minimum of one light entry window and a minimum of one light exit window, with a considerable portion of the light that enters via the light entry window or windows exiting via the light exit window or windows.

2. A diaphragm for light inserts according to Claim 1, characterized in that the diaphragm allows the light required to cure the filling material in the tooth cavity to enter only via the light path of the light insert that leads from the light entry window to the light exit window.

3. A light exposure device for light inserts according to Claim 1 and/or a diaphragm according to Claim 2, characterized in that the cross section of the light exiting area of the light exposure device is adjusted to the cross section of the light entry window of the light insert.

4. The light exposure device according to Claim 3, characterized in that the intensity and/or the divergence or the convergence of the light exiting from the light exposure device are controllable.

5. The light exposure device according to Claim 3, characterized in that a shaking device is integrated into the light exposure device, by means of which shaking device it is possible to generate vibrations and to transmit these to the light insert.

6. An adapter for coupling the light into the light insert according to Claim 1 and/or a diaphragm according to Claim 2, characterized in that said adapter and/or diaphragm make it possible to ensure an adjustment of the light-transmitting cross section of the light exit area of the light exposure device to the cross section of the light entry window of the light insert, with the adapter, in addition to a mechanical detachable connection to the light insert and/or to the light exposure device, also making it possible to interpose a light conductor.

7. The light inserts according to Claim 1, characterized in that the light insert consists mainly of a suitable organic material.

8. The light inserts according to Claim 1, characterized in that the light insert consists mainly of a suitable inorganic material.

9. The light inserts according to Claim 1, characterized in that the light insert consists of a suitable combination of an organic and an inorganic material.

10. The light inserts according to Claim 1, characterized in that the light exit window or windows of the light insert are additionally coated with an uncured or partially cured light-curable plastic filling material.

11. The light inserts according to Claim 1, characterized in that the light entry window or windows of the light insert have available surfaces and/or connections which promote the light transmission between the light exposure device and the light insert and between the light exposure device, adapter, and light insert.

12. The light inserts according to Claim 1, characterized in that the light entry window or windows of the light insert or portions thereof are designed to be convex or concave.

13. The light inserts according to Claim 1, characterized in that the light exit via the light exit window or windows is facilitated by one or several suitable light scattering centers and/or by one or several partially permeable, reflecting, or mirroring surfaces on the surface of or inside the light insert body.

14. The light inserts according to Claim 1, characterized in that the light insert has a cavity starting at the location of the light entry window and being coverable so as to be permeable to light or being open toward the light entry window, with this cavity being suitable for the light coupling.

15. The light inserts according to Claim 1 and/or Claim 14, characterized in that the light coupling is implemented by means of a light conductor which leads to the light entry window of the light insert or into the cavity inside the light insert, with the connection between the light conductor and the part of the light insert that remains in the filling being designed so as to be a permanent or a plug-in connection.

16. A light conductor for light inserts according to Claim 15, characterized in that both its geometry its light distribution make the light conductor suitable for a light flux passing through the entire area of the light exit window of the light insert into the surrounding area of the light insert.

17. Fitting bodies for the light inserts according to Claim 1, characterized in that these fitting bodies can be inserted or cemented into the cavity that is formed after the light insert has been removed from the cured filling material.

18. The fitting bodies for the light insert according to Claim 14, characterized in that these fitting bodies can be inserted or cemented into the cavity of the light insert.

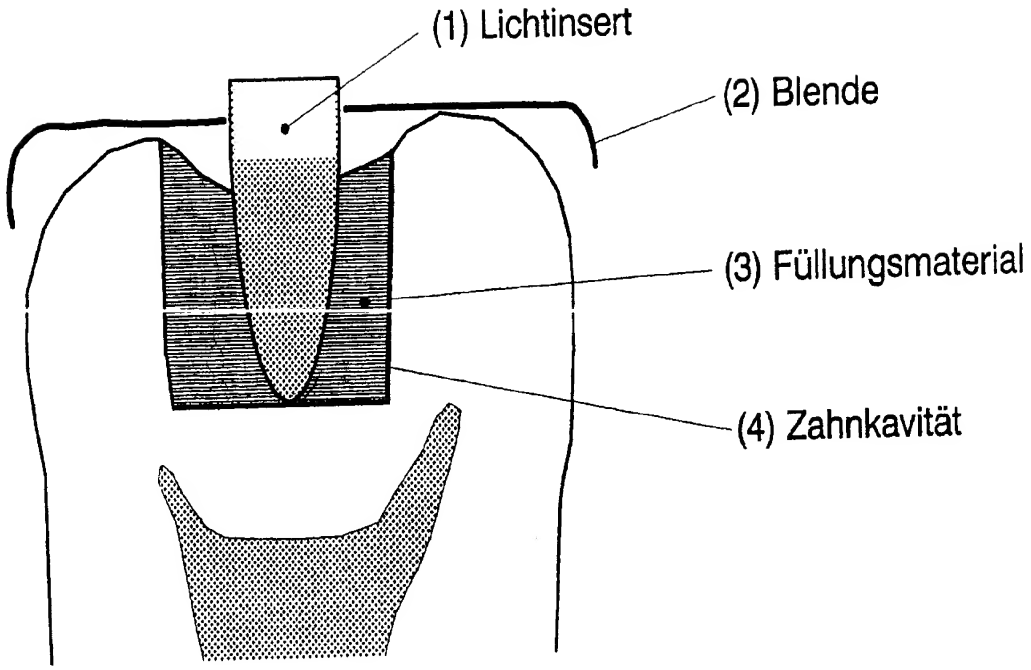

Figure 1. Light insert in the filling of the tooth

Key: 1 Light insert
2 Diaphragm
3 Filling material
4 Tooth cavity

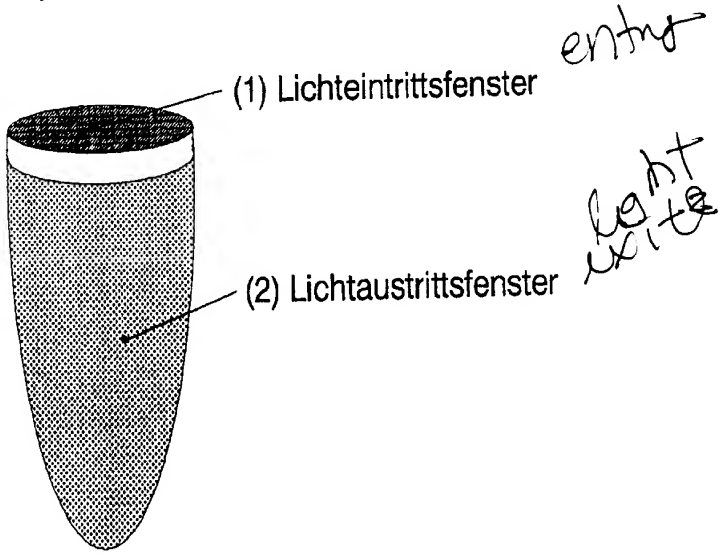

Figure 2. Light insert

Key: 1 Light entry window
2 Light exit window

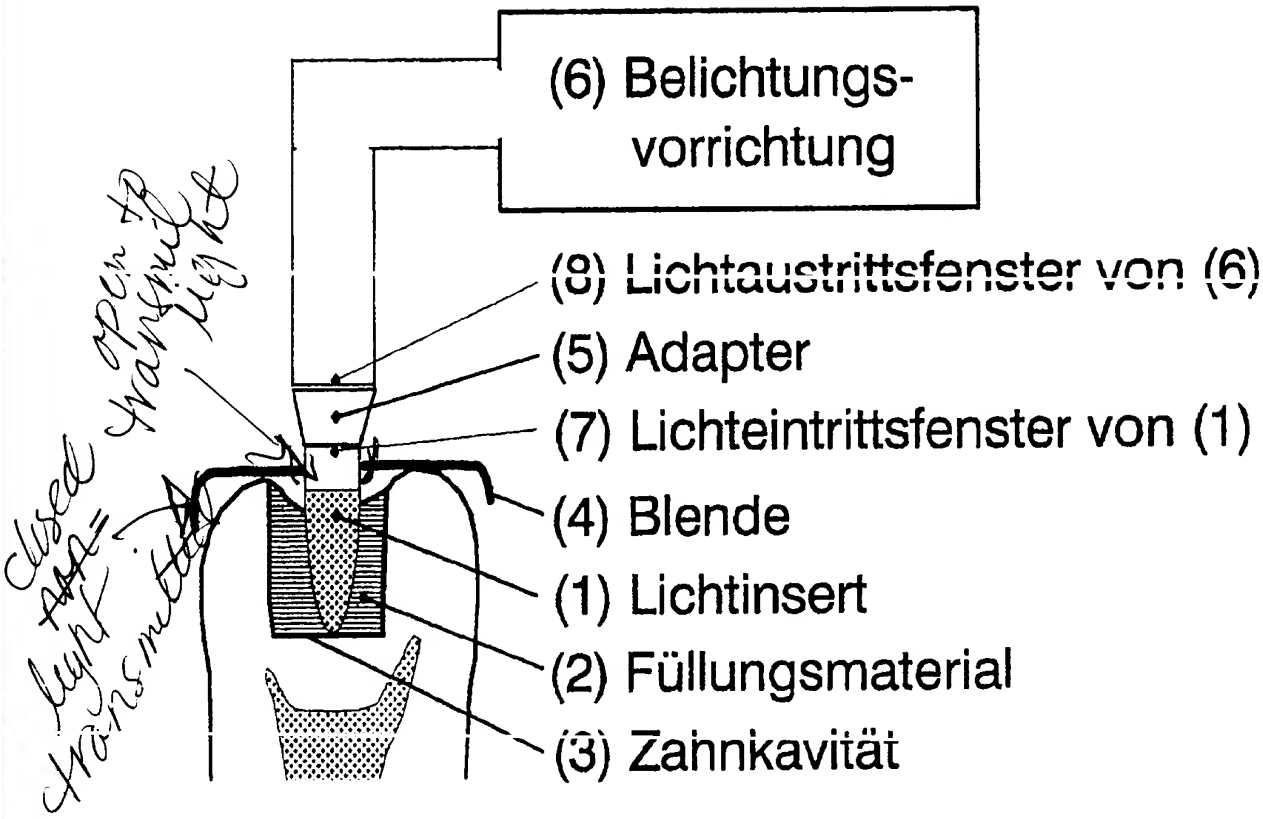

Figure 3. Components for the production of dental fillings leaving no marginal gaps

Key:
1 Light insert
2 Filling material
3 Dental cavity
4 Diaphragm
6 Light exposure device
8 Light exit window of (6)
7 Light entry window of (1)